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THESIS

SWEEPING CHANGES FOR MINE WARFARE: CONTROLLING THE MINE THREAT

by

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SWEEPING CHANGES FOR MINE WARFARE:
CONTROLLING THE MINE THREAT
by

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ABSTRACT

This thesis proposes that the U.S. Navy deter and, if necessary, combat potential minelayers by pursuing a "pro-active" offensive mine warfare strategy. Central to this proposed strategy is the development, acquisition, and use of Remote Controlled (RECO) mines. It is argued that, given the historical problems the United States has had in the area of naval mine warfare, a strategy aimed at the aggressive deterrence of enemy mine laying be embraced so as to project forces ashore in future amphibious operations.

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EXECUTIVE SUMMARY

Historically, the United States has failed to fully appreciate the overall importance of mine warfare and, more specifically, the strategic importance of preventing an enemy from laying mines.

This thesis proposes a "pro-active" strategy for offensive mining and mine countermeasures with the goal of deterring an enemy from laying mines. The proliferation of mines and mine technologies has brought about a situation in which "traditional" mine defensive measures have become increasingly less cost-effective. Simply put, it has become increasingly expensive and risky to try and offset each incremental advancement in mine capabilities with "passive" mine countermeasures alone. It is necessary therefore that the U.S. Navy consider new options to deter and, should deterrence fail, combat future mine threats. Through the employment of Remote Controlled (RECO) mines, the United States may not only be able to deter an aggressor from laying mines, but may also achieve a tactical advantage in the event such deterrence fails. The long-term benefits of such an "offensive" mine warfare strategy would be two-fold. First, it would send a strong signal that the United States is committed to the safe passage of U.S. naval vessels and freedom of the high seas. And secondly, it would produce certain important tactical advantages were an aggressor nation to engage in mining nevertheless.

The United States achieved a decisive victory in Desert Storm. The victory might have lost some of its luster however, if the coalition offensive had required an amphibious assault against Iraqi defenses in Kuwait. The reason would have been the potentially high cost involved in breaching the enemy's offshore minefields.

As the U.S. military enters an era of uncertainty and dwindling resources it is incumbent that defense funds be allocated in a judicious and wise manner. Mines have been, and will always be, a significant part of every future naval battle and the United States must refocus its mine warfare strategy to address this vital concern. The United States must embrace a strategy that is aimed at deterring a nation from laying mines if it is to project forces ashore in future conflicts.

I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to analyze the deterrent effect that a "pro-active"[1] mine warfare strategy will have on an aggressor who engages in mine laying activities. A pro-active offensive mining and mine countermeasures (MCM) strategy may not only enable the United States to better deter a potential enemy from laying mines, but may also send a strong "signal" to that nation (as well as other nations) that retaliation will be swift and severe for those who are not deterred. Various offensive mining and MCM strategies are offered in this study, but one which seems to be particularly attractive includes the use of Remote Controlled (RECO) mines and Identification Friend or Foe for Minefields (IFFM). This technology has been available since the early 1980s, but so far has not been accepted for political reasons. The following chapters illustrate the advantages as well as the disadvantages to the United States of employing a pro-active mine warfare strategy.

The proliferation of mines and mine technology is also examined for the simple reason that, over the past few years, it has allowed even the poorest nation the ability to possess state-of-the-art mine technology at a relatively low cost. This sobering reality, coupled with the limited success the United States has historically experienced in the area of mine warfare, should convince the United States to approach the problem of the "weapon that waits" differently.

The Joint Chiefs of Staff (JCS) Rules of Engagement (ROE) that govern the actions of an on-scene commander of a naval vessel are also examined to illustrate the vulnerable and potentially life threatening situation the commander of a naval vessel is

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[1]The 1994-1995 U.S. Navy Mine Warfare Plan, Second Edition, highlights the vital importance of a "pro-active" offensively orientated mine warfare strategy. Mine warfare encompasses both mining and mine countermeasures activities. Offensive mining includes the employment of mines to deter or restrict an enemy from mining. Offensive MCM includes actions taken against an enemy or intelligence gathered to prevent mines from being laid in the first place.

in once mines are laid in international waters. Current ROE concerning the "right of self-defense" do not allow an on-scene commander the freedom to neutralize an enemy vessel confirmed to be laying mines. Therefore, a ship and its crew are placed in a life threatening situation with limited retalitory actions available to them.

B. BACKGROUND

Throughout history, mine warfare has been perceived as an unglamorous and insignificant dimension of naval strategic planning. Recent world events indicate that there will be more rather than fewer regional conflicts. Some will undoubtedely involve mines. Therefore, the United States must be strategically and tactically ready to deter and if necessary compel others from using mines. Mines, if left uncontested, will impede the safe execution of U.S. naval activities and constrain the ability to pursue the Nations interests.

The threat of naval mines is not new. The world has had experience with various sorts of mine warfare for over 200 years. Although the modern mine bears little resemblance to its nineteenth century antecedent in terms of technical sophistication, the original definition given to what then were called "torpedoes" still holds true: an unattended underwater explosive.

Anti-ship devices of one sort or another have been used since Grecian times, but their failure rate was extremely high. The problem that plagued the early proponents of mine warfare was in designing a firing system that would fire at the most opportune moment - preferably when an enemy ship was within striking distance - not when the mine was being planted, which was frequently the case. The development of mines has come a long way since then and today just about anyone (i.e., non-state actors and international terrorists) can acquire mines of various sophistication. (See Appendix A).

During the 1950s and early 1960s, the United States and other NATO navies were extremely mine-conscious, building several hundreds of minesweepers and minehunters. But then came a 20 year hiatus in the U.S. Navy's construction of MCM ships. Yet, in every conflict in modern history in which the United States has participated "it has been

required to use some form of mine countermeasures forces, ships, helicopters or both."[2]

The proliferation of modern mines and mine technologies will almost certainly compound the mine threat to world sea communications in the future. The most effective means of countering this threat appears to be an aggressive strategy of deterrence toward those who engage in mining activities.

Mine warfare is, and will always be a vital concern to the U.S. strategic objective of "maintaining control of the seas" and safely projecting forces ashore in support of amphibious operations. Mine warfare, and more importantly, U.S. credibility, are at a "pivotal point" in history, and the humbling lessons learned from past conflicts should not be neglected any longer!

C. THESIS OBJECTIVE

The objective of this thesis is to illustrate the potentially dangerous mine warfare situation that the United States will undoubtedly face as it attempts to project forces ashore in support of amphibious operations. Its aim is to re-focus current mine warfare strategy from the traditional defensive strategy to a more offensively orientated, or "pro-active" strategy. It is hypothesized that this type of strategy will deter a potential opponent, thereby enhancing the United States tactical advantage in a mine related conflict and enable U.S. naval forces to safely control the seas.

D. SCOPE

This thesis focuses on mining and mine countermeasure strategies that are accepted in theory but frequently neglected in practice. It identifies tactics that if employed could prevent a nation from laying mines, or give the United States a tactical advantage if deterrence should fail. The laws, regulations and ROE pertaining to mine warfare are analyzed to determine the most effective method, or combination of methods, that would deter a nation from initiating a mining campaign. Realizing that a "pro-active"

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[2]Wettern, Desmond, "Coping With The Hidden Threat," Sea Power, March 1991, p. 40.

strategy has its drawbacks in terms of escalation and political negotiating, it is suggested that the implications of not embracing such a strategy, would be far more detrimental to the United States in the long run.

E. RESEARCH LITERATURE AND METHODOLOGY

Research data was obtained from official government directives and policies, journals, previous theses, Department of Defense and Navy regulations and manuals, and personal interviews. Information on Remote Controlled (RECO) mines and Identification Friend or Foe for Minefields (IFFM) was obtained from the Mine Warfare / EOD Branch (N852) and the Warfare Analysis Department of the Naval Surface Warfare Center, Dahlgren Division, White Oak Detachment at Silver Spring, Maryland.

Research was conducted via personal interview and telephone interviews with various mining and mine countermeasures personnel. Interviews with mining personnel centered around the technological aspects of RECO and IFFM, as well as the current status of both capabilities. Interviews with mine countermeasures personnel dealt with the advantages and disadvantages of a offensively orientated MCM strategy.

F. ORGANIZATION OF THESIS

Chapter II of this thesis addresses the historical problems inherent with mine warfare as well as the various types of minefield typically employed.

Chapter III provides a historical case analysis of mine warfare operations to illustrate how mines or the threat of mines have significantly altered the outcome of numerous naval battles.

Chapter IV focuses on the proliferation of mines and mine technologies. Specifically, the various mines that are on the open market and the technological capabilities available to enhance the characteristics of these mines.

Chapter V introduces the use of offensive mining through the employment of Remote Controlled (RECO) mines and Identification Friend or Foe for Minefields (IFFM) which adds a greater degree of safety and tactical maneuverability to RECO minefields.

It also proposes four generic mining strategies that would enable the United States to achieve tactical superiority of the sea, if deterrence should fail. And finally, it addresses offensive mine countermeasures capabilities and the vital importance of accurate and timely intelligence gathered through diligent reconnaissance and surveillance assets.

Chapter VI introduces the JCS Rules Of Engagement (ROE) that govern the actions of an on-scene commander when confronted with a vessel known to be laying mines.

Chapter VII highlights the legal implications associated with mines and specifically, remote controlled mines.

Chapter VIII contains an analysis of the various tactics suggested as well as specific recommendations for the future.

II. MINE WARFARE

A. INTRODUCTION

This chapter presents a basic overview of naval mines and mine warfare. It also highlights the historical difficulties that most countries have had countering mines. The use of Remote-Controlled (RECO) mines is introduced in this chapter to develop an understanding for its effectiveness and the flexibility it can afford the United States, politically as well as strategically.

B. THE CURRENT DILEMMA

> ...When you can't go where you want to, when you want to, you haven't got command of the sea. And command of the sea is a rock-bottom foundation for all our War plans. We've been plenty submarine-conscious and air-conscious. Now we're going to start getting mine-conscious - beginning last week.[3]
>
> Admiral Forrest Sherman, USN
> Chief of Naval Operations, 1950

This quote sums up the unfortunate situation that still faces the United States mine warfare community more than four decades later. As a maritime nation and a proponent of free and unmolested access to the seas by all peaceful nations, the United States can no longer afford to minimize the crucial mine warfare lessons of the past. Mines have always been a powerful political tool as well as a show-stopping military weapon. They have become even more important today as the poor man's weapon of choice that can frustrate the movements and greatly impede the overall success of even the strongest navies. U.S. national security and defense planning clearly rests on the ability to use the seas freely. This demands that, while the United States wrestles with the long-term problem of clearing mines, it should meanwhile focus on the near-term strategic and

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[3]Cagle, M.W. and Manson, F.A., The Sea War in Korea, 1957, p. 142.

tactical advantages of offensive mine warfare as a potential deterrent. This "pro-active" MCM strategy may not only deter an aggressor, but it can also signal U.S. resolve that may thwart others in the future.

C. DEFINING MINE WARFARE

> A war in which enemies seldom meet and battle is rarely joined, but death and destruction always mark the field. Where the big ships fight their battles, and the little mine craft have already been to do their dull and dirty duty, in which there is no glory. Where the fighting fleets sail to victory, there are the seas of glory. But where the little ships go, there is the most dangerous sea. This is mine warfare.[4]

Mine warfare is by definition the strategic and tactical use of sea mines and their countermeasures. It constitutes both the laying of mines with the aim of sinking the opponent's shipping, or at least hinder his use of the seas, and mine countermeasures, which include all measures for countering the mine by reducing or preventing danger or damage to ships and personnel.[5] Mining and mine countermeasures are two distinctly different operations. Anything undertaken actively (sweeping or hunting) or passively (reconnaissance and surveillance) to defeat mines can be defined as part of MCM. Traditionally viewed as a defensive measure, MCM means much more in fact. Since the American Civil War, MCM craft have often been at the forefront of offensive operations, leading strike forces into and out of ports, and clearing channels and staging areas in advance of the fleet. The MCM force motto is: "Where the fleet goes, we've been."[6] In a broader sense, offensive MCM operations can involve most naval assets and may require the assistance of land based forces as well. The 1994-1995 Mine Warfare Plan

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[4]Lott, Arnold S., LCDR, USN, Most Dangerous Sea, 1959, p. 3.

[5]Van Waning, J. Jan W., "Naval Mine Warfare," International Military and Defense Encyclopedia, Volume 4, 1993, pp. 1759-1760.

[6]Melia, Tamara M., Damn The Torpedoes, A Short History of Naval Mine Countermeasures 1777-1991, p. 4.

emphasizes the fact that the most effective counter to sea mines is not their clearance, but the prevention of their being laid in the first place.[7] Therefore, offensive mine warfare strategy may be crucial to the success of an amphibious assault. Today, MCM operations aim at reducing the threat of enemy mining by both offensive and defensive operations against enemy mine laying agents and their supporting facilities. This is a pro-active MCM approach that the United States has been reluctant to pursue for political and military reasons, but one that could send a clear and decisive "signal" that the United States is willing to use force to maintain freedom of the seas.

In order to examine why the U.S. Navy, has not sustained an enthusiastic interest in mine warfare one must focus on the lessons learned, and most importantly, those not learned throughout history.

D. THE ROOT OF THE PROBLEM

Many naval officers still see mine warfare as a rather undignified and insignificant task. Recent conflicts have shown, however, that disposing of even the simplest and old-fashioned mines may require the use of sophisticated and expensive resources or, more importantly, the altering of strategies and tactics. Many naval officers would rather echo the exasperated command of Flag Officer David Farragut when he entered Mobile Bay on 5 August 1864, exclaiming, "Damn the torpedoes, full steam ahead."

The U.S. Navy must begin building a foundation of officers and mine warfare experts who are not only well trained but who will build on the knowledge and experience of others in order to construct a community of professionals capable of countering one of the most difficult threats of the 21st century. The absence of a dedicated "mine warfare" community (albeit not individual dedication) can be summed up in the following statement:

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[7] 1994 Mine Warfare Plan, p. 32.

> The largest single deterrent to an effective U.S. mine warfare force has been our failure to train and develop mine warfare officers. Officers from all naval communities are assigned generally on a one-time haphazard basis. There is no progression in the community because there is no community...The first action necessary to turn things around for the U.S. Navy in mine warfare must be to remove the negative stigma of [mine warfare]...[8]

As Admiral Zumwalt, former Chief of Naval Operations said, "No union has a vested interest in mines, which have no bridges for captains to pace."[9]

The U.S. Navy is arguably no better prepared strategically for mine warfare today than it was when it lost control of the seas to Korean minefields at Wonsan in 1951.

> The main lesson of the Wonsan operation is that no so-called subsidiary branch of the naval service, such as mine warfare, should ever be neglected or relegated to such a minor role in the future. Wonsan also taught us that we can be denied freedom of movement to an enemy objective through the intelligent use of mines by an alert foe.[10]

Although there are many technological reasons why the United States is no better prepared for a mine warfare battle today, the most important ones center around current U.S. strategy and tactics. U.S. mine warfare strategy and tactics claim to support the "pro-active" use of offensive mining and mine countermeasures, but the reality is that it is neglected as a viable option. The lack of a "true" mine warfare doctrine also illustrates this point.[11] But there are other reasons as well, that extend beyond the material and doctrinal inadequacies. Intra-service rivalry among the Navy warfare communities,

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[8]Rogers, Edward, LT, USN, "Mines Wait But We Can't!" Proceedings, August 1982, p. 51.

[9]Zumwalt, Elmo R., On Watch: A Memoir, 1976, p. 64.

[10]Cagle, M.W., and Manson, F.A., p. 151.

[11]Interview with Capt. Franklin G. (Mike) West, USN (Ret), on 25 August 1994 at the Naval Postgraduate School, which pertained to the Navy's current study of a mine warfare doctrine that will encompass new strategies and tactics for mine warfare.

mismanagement, and lack of a long term plan have forced the mine warfare community to take a back-seat to other more "vital" missions. Unlike other NATO navies, the U.S. Navy does not have a foundation of trained mine warfare personnel. There is no officer community born and bred to the mine warfare service. Mine warfare billets, ashore and afloat, are manned for the most part by officers from other warfare communities. The manning of the Navy's ocean minesweepers (MSOs) clearly demonstrates this problem. The commanding officers of the MSOs view their tours as early commands as they progress from Executive Officer of a frigate to Commanding Officer of a "real" surface combatant. They are hard pressed to meet the normal administrative shipboard requirements associated with their first commands, hence they do not have enough time to acquire expertise in their ships' warfare specialty. Today's commanding officers of MCM vessels are no better prepared tactically to hunt mines than a destroyer officer is to assume command of a submarine. The MCM expert on board a U.S. minesweeper is typically a first tour lieutenant (junior grade). But the most obvious problem hampering the mine warfare community has been its failure to train and develop mine warfare officers. Officers from all naval communities are assigned generally on a one-time, haphazard basis. Therefore, there is no progression within the community. As Admiral Kidd said just prior to the clearance operation in Haiphong harbor in 1973, "Minesweeping seems to acquire sex appeal once every 25 years [when a crisis occurs]. The intervening hiatus is quite a hurdle to overcome."[12]

Tamara Moser Melia, naval historian and mine warfare expert explains:

> It is difficult for the uninitiated to separate the excuses from the reasons why we have repeatedly failed to sustain effective mine countermeasures in the U.S. Navy. Lack of a basic mine warfare knowledge throughout the U.S. Navy generally results in over generalization about causes and effects, leaving many naval officers with the impression that the excuses often offered are adequate reasons why we are not more effective. Such attitudes increase, rather than decrease institutional prejudices against the

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[12]Kidd, Issac., Admiral, USN, Chief of Naval Material, Message to CINCPACFLT, February 1973, cited in Melia, p. 111.

development of the adequate, and often expensive, ways to truly increase the operational effectiveness of our mine forces. And no matter what great platforms and systems we can develop to solve the MCM problems, institutional prejudice itself can continually cripple our mine warfare effectiveness, as we saw most recently in Desert Storm.[13]

E. TYPES OF NAVAL MINES

Modern naval mines are versatile and variable weapons. They range from relatively unsophisticated and indiscriminate contact mines to highly technical, target-selective devices with state-of-the-art homing guidance capability. Today's mines may be armed and or detonated by physical contact, acoustic or magnetic signature, or sensitivity to changes in water pressure generated by passing vessels. Mines may be deployed by air, surface, or subsurface platforms. Armed mines are either planted with all safety devices withdrawn or they are armed following emplacement but will not detonate until certain parameters are satisfied. So-called "controlled" mines (including mines with remote control activation devices) have no destructive capability until affirmatively activated by some form of arming order.[14]

There are two main categories of mines: controlled and independent mines. Controlled mines can be activated or de-activated by the user after they have been laid. The earliest controlled mines consisted of a series of large explosive charges deposited on the seabed (or riverbed) connected by electrical cables to a position on the shore overlooking the minefield. When a target was observed passing within the vicinity of the mines, an electrical signal from ashore triggered detonation. Modern cable-controlled mines may contain detecting mechanisms that signal the presence of a ship or submarine

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[13]Comments taken from a speech given as part of the Carl Menneken Lecture series in Mine Warfare, to the Undersea Warfare Curriculum of the Naval Postgraduate School, by Tamara M. Melia, on 28 July 1994.

[14]Naval Warfare Publication (NWP) 9, Commander's Handbook of the Law of Naval Operations, Conventional Weapons and Weapons Systems, Chapter 9, paragraph 9.2.1., p. 9-4.

to a remote station, or they may be operated in conjunction with some separate means of detection. Controlled mines have typically been employed in protective or defensive minefields, but subsequent chapters illustrate the advantages of using remote controlled (RECO) mines for "offensive" purposes, as well as a long-term deterrent.

Independent mines rely on their own sensors for firing. This type of mine can be further divided into contact mines and influence mines. A contact mine is designed to explode when it makes physical contact with a target. A contact mine may be set off by direct contact with the hull of a ship: when the hull or propellers catch a buoyant line attached to one of the horns or switches of the mine (the snagline mine); or by the ferrous hull touching a copper or brass antenna fitted to the mine. The latter sets off a galvanic action that fires the mine (antenna mine).

Influence mines are actuated by the effect of a target on some physical condition in the vicinity of the mine or on radiations emanating from the mine. The first influence mines were used in World War II, and included magnetic devices, which relied for their activation on a disturbance of the earth's magnetic field. More recently, other actuation methods, such as the use of the electrical potential within the water (the underwater electric potential mine), have been developed. Modern influence mines normally have a combination of two or more sensor types in their firing circuits (combined influence mine).[15]

F. MINING OPERATIONS

History is replete with examples of the mine's influential role in naval warfare. The benefits of a vigorous mining capability go beyond the ability to just sink ships. Mines present a threat to a much broader range of targets than any other naval weapon and can affect maritime operations across the full spectrum of conflict. The mere threat of a mine is sometimes all that is needed to alter an enemy's battle plans.

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[15]Van Waning, J. Jan W., "Naval Mine Warfare," International Military and Defense Encyclopedia, Volume 4, 1993, pp. 1755-1761.

The mine's all-weather, 24 hour a day potential to inflict extensive destruction provides a potent military and political presence. The mine is unobtrusive and does not require platforms on station or constant monitoring. Minefields, unlike other weapons, are usually invisible and do not lend themselves easily to TV or other graphic adversarial propaganda. A minefield is a collection of explosive devices positioned to impose strategic or tactical constraints on the operational use of an area by surface ships or submarines. It is not a stand-alone weapon; it must be considered part of a total strategic network in a military campaign. The effects of a minefield can be two-fold: it can physically sink or damage ships, and it can psychologically threaten or exhibit the potential to sink or damage ships.[16]

Because a declared minefield can only cause damage and casualties if the enemy takes the risk of transiting, the minefield can form an intermediate step between negotiations and the escalation of a conflict. Minefields are laid for offensive, defensive, or protective purposes, depending on the strategic or tactical objective in mind. The type of minefield employed is usually dependent on the available numbers and types of mines and minelayers, on geographic and environmental circumstances, and on possible enemy reactions and countermeasures.

The objective of strategic mining campaigns is to deny the enemy free access to or use of the sea areas considered vital to one's own war effort, or to reduce and impede the enemy's warmaking potential. Depending on the importance of the threat, a mining campaign can be directed against naval surface forces, submarines, or seaborne communications. Sustained attrition mining is essentially strategic in nature.

Tactical mining is used to support a limited military objective in time and scope. Historically, the mine was not an effective tactical weapon because its deployment required too much preparation time (i.e., arming, loading, clock setting, etc.) for immediate use. Modern mines are much more suitable for last-minute deployment but limited delivery platform availability is still a major constraint: It is for this reason that

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[16]NWP 27-4, "Mining Operations" Chapter 3, Paragraph 3.1., p. 3-2.

the RECO mine becomes an attractive alternative because its deployability is far less dependent on last-minute availability of delivery platforms.

G. SUMMARY

This chapter illustrated the problems plaguing the mine warfare community as well as suggestions for improvement. Mines will be a significant factor in future naval operations and the success of the Navy in mine related conflicts depends on its ability to educate military decision makers on its future importance.

Mines are also examined in this chapter to highlight the unique qualities that make them the "weapon of choice" for most nations. Most nations have traditionally viewed mines as cheap, reasonably simple, and reliable weapon whose attributes have long constituted their fundamental appeal. Because of these characteristics, the mine is producible in great numbers at relatively low costs; large numbers can be stockpiled without a constant need for expensive maintenance routines; they can be kept in the inventory for a long time; and older mines are readily adaptable to more modern fusing techniques. The mine is a cost-effective weapon for another reason as well: its defeat requires a disproportionately great investment in forces and technology. For those who must wage naval war, these virtues are impressive.

Therefore, possessing a RECO capability becomes an attractive alternative to reacting to another nations mining campaign. RECO would allow the United States the flexibility of laying mines prior to, or shortly after, the outbreak of hostilities. This is one of the many advantages of RECO, for a mining campaign with mines that are turned off (unarmed) can be initiated at the first indication of hostilities and turn on (armed) if and when the situation escalates.

Before changes to U.S. mine warfare strategies and tactics can be implemented, mine warfare needs to address the mindset of the mainstream Navy - the users of MCM services. Operational commanders of major naval forces must be taught that their interests, the Navy's, and that of their nation, are best served through the initiation of an effective mine warfare strategy. It must be understood that mine warfare is a vital part

of all naval combat operations and to disregard the lessons of past conflicts will place the United States in an extremely vulnerable position as it attempts to project forces ashore in future conflicts.

Whosoever can hold the sea has command of everything.
--Themistocles (524-460 B.C.)

III. MINE WARFARE CASE EXAMPLES

A. INTRODUCTION

The following case histories are chosen to illustrate the strategic and tactical lessons learned from mine warfare. Mines have crippled, stalled, and forced changes in battle plans throughout history, and these historical examples represent the overall importance that mines have played in past conflicts, as well as the strategic advantage of offensive mining and offensive mine countermeasures.

B. THE CIVIL WAR

1. Mobile Bay

One of the older lessons in mine warfare goes back to Flag Officer Farragut's dramatic penetration of the mine infested waters of Mobile Bay in 1864. The image of Farragut created in the press and historical records is that of a daring man who risked his life (and that of his crew) in the face of an unknown mine threat. The facts of the situation are that Farragut was extremely worried about the mine threat and its catastrophic potential. One night, Farragut's flag lieutenant and personal friend, LT. Watson, volunteered to personally survey the waters leading into Mobile Bay. Watson's innovative reconnaissance techniques led to the discovery of numerous mines, which he marked as accurately as possible, and reported back to Farragut. Watson concluded that, due to their physical condition, the majority of the mines did not pose a risk to Farragut's fleet. Farragut decided to enter the harbor just slightly astern of the sloop *Brooklyn* which was rigged with a rudimentary mine catcher. No sooner had the lead ship, the *Tecumseh*, entered the harbor, when it struck a mine and quickly sank to the bottom of the bay. Farragut was in a vulnerable position and had to decide whether or not it was worth the risk to steam on. He challenged the minefield and halfway into it was heard barking the order: "Damn the torpedoes, full speed ahead."[17] Watson's brave efforts no doubt set the

[17]Melia, p. 3.

stage for the success of the mission, for the intelligence he provided about the condition of the mine line greatly influenced Farragut's decision to take the risk. Farragut prepared to battle the mines as carefully as he prepared his vessels for the fight. He obtained sufficient information about the condition of the mines and the location of the mine line to make a calculated decision. Farragut did not merely damn the torpedoes at Mobile Bay, but instead hunted, examined, and disabled several mines before steaming into the bay. His meticulous approach is a crucial lesson in risk assessment and points to the importance of accurate and timely intelligence.

C. WORLD WAR I

1. The Dardanelles Straits

In 1915, the British and French fleets attempted to force the narrow Dardanelles Straits in an effort to attack the Germans from the south, drive a wedge between Turkey and Bulgaria, and open critical lines of communication with their Russian allies. The Turks had reportedly begun to mine the Straits in 1914 with drifting mines in what arguably became one the most decisive mining campaigns ever initiated.[18]

The allies initially planned to force the Straits by naval attack alone; success was completely dependent on the ability of slow minesweepers to clear a passage through the heavily protected straits. In order to avoid being spotted by the enemy's gunners ashore, the minesweepers, which were manned by civilians, made numerous attempts under the cover of darkness, to sweep the Straits. Without protective gunfire support, they had little chance. On 18 March 1915, the Anglo-French naval force decided to go ahead with its assault anyway. Two battleships and two cruisers were lost in the attempt. The problem was this: "The battleships could not force the Straits until the minefield had been cleared - the minefield could not be cleared until the concealed guns which defended them could

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[18]J.S. Meacham in "Four Mining Campaigns: An Historical Analysis of the Decisions of Commanders," Naval War College Review, June 1967 cites Turkish records to the effect that the first mines were laid on 3 August 1914. Most mines were actually laid after 1 January 1915.

be destroyed, and they could not be destroyed until the Peninsula Gallipoli was in (allied) hands; hence, (the allies had) to seize it with the Army."[19] The disastrous Gallipoli landing was the eventual result of an effective turkish mining campaign.

D. WORLD WAR II

1. Normandy

As might be expected, mines were a significant factor in the Allied pre-invasion planning of D-Day in June 1944. The Allies were encouraged by their successful attacks on the German minelayers during the months preceding the landing, but insufficient intelligence with respect to recent German innovations in mine technology almost brought catastrophe. Unbeknownst to the Allies, the Germans had developed a pressure mine, called "Oyster." During the early months of 1944, Hitler ordered that 4,000 Oyster mines be sown around Normandy, Le Havre, and Cherbourg. The Germans, guessing that the invasion would take place before the end of May, tailored their mines to sterilize themselves by the end of the month to set the stage for friendly E-boat operations in that area in early June. Six days before the Allies crossed the channel thousands of Nazi mines flooded and sank themselves as planned. The Allies were extremely fortunate that their losses were limited to just 50 small landing craft.[20] The casualties would surely have been higher if the Germans had "guessed" the actual Allied invasion date correctly. Once again, the importance of accurate and timely intelligence cannot be overestimated.

2. Japan

a. Haiphong, 1943

On 16 October 1943, a single U.S. B-24 bomber dropped three mines in Haiphong harbor. A month later another B-24 dropped three more mines there. The first drop resulted in the sinking of the 3,000-ton freighter *Shozan*; the second, the 500-ton

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[19]Meacham, cited in Gregory K. Hartmann, Weapons That Wait: Mine Warfare in the U.S. Navy, 1979, p. 47.

[20]Lott, p. 185.

Totsuya. A ten-ship Japanese convoy, afraid to enter the port, loitered outside the harbor for several hours, then decided to head for Northern Hainan Island. There, the 14th Army Air Force detected and sunk six of the ships.[21] A small 30-ton ship was later sunk by one of the remaining mines, and the port was subsequently closed to steel-hulled ships for the remainder of the war.

b. Palau Atoll, 1944

On 30 March 1944, U.S. planes from three aircraft carriers dropped mines at the entrance to the harbor at Palau Atoll. Thirty-two Japanese ships were inside the harbor. Although the Japanese crews knew they had been detected, they preferred to stay put, rather than to risk the "invisible" enemy. As a result, the ships became sitting ducks for the subsequent air raids: 23 were sunk. The United States added insult to injury and dropped more mines inside the harbor. The Japanese thought they had done a sufficient job of clearing the mines until the first ship hit a mine and was severely damaged. Subsequently, the Japanese abandoned Palau as a naval base.

c. Operation Starvation, 1945

During 1945, the United States conducted an extensive offensive mining campaign aimed at rupturing the Japanese economic and military supply lines. "Operation Starvation" began in March 1945, and included the mining of Sasebo, Kure, and Shimonoseki Strait. The Japanese were forced to radically alter their shipping routes. The battleship *Yamato* was diverted from Shimonoseki Strait to Bungo Strait, was sighted, attacked, and sunk. The Japanese incurred considerable losses trying to navigate the hazardous waters, but they had little choice: they had to either face the risk of the mines, or be subject to economic starvation. Once the United States realized that the Japanese were challenging the minefields, it began to lay mines with a more sensitive setting so they would detonate only when a target was a sure kill. The goal switched from deterrence to ship-sinking.

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[21]Lott, p. 218.

Operation Starvation was one of the many campaigns that contributed to Japan's decisive defeat in World War II. The battles of the Coral Sea, Midway, Tarawa, Peleliu, and Leyte Gulf unquestionably brought the war closer to an end, but the slow process of blockading the distant and critical sea lanes of Japan reduced her to economic, industrial, and personal starvation.

The U.S. mining campaign was successful beyond expectation, as it accounted for the sinking of 670 Japanese ships and the loss of over 40 percent of Japanese merchant crews. In addition to bottling-up Japanese ships, the Americans kept Japanese minesweepers busy, with over 20,000 men and 349 ships dedicated to clearing the sea lanes and harbors. Speaking for all Japanese mine experts, Captain Kyuzo Tamura, IJN, told postwar interrogators:

> The results of the B-29 mining were so effective against the shipping that it eventually starved the country. I think you probably could have shortened the war by beginning earlier.[22]

Only 15 minelaying B-29's were lost during Operation Starvation, which equates to one lost plane for every 45 ships that were sunk. The effects of a well planned offensive mining campaign can be staggering, for one of the little known but highly humanitarian aspects of mine warfare is that:

> A mine blockade essentially enables the winner to win without killing. Enemy ships lost in a minefield enter it by their own choice; the enemy is free to keep his ships in port and save them if he wishes. But more importantly, mines never destroy homes, hospitals, or industrial facilities necessary for peacetime rehabilitation, nor do they indiscriminately wipe out non-combatant civilians.[23]

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[22]Lott, p. 227.

[23]Lott, p. 223.

E. THE KOREAN WAR

1. Wonsan

During the early months of the Korean War, a planned amphibious assault at Wonsan was "delayed for weeks as U.S. and allied minesweepers in what became known as Operation Yo-Yo" cleared the approaches to the beach.[24] The reason was that the North Koreans had planted over 3,000 moored and ground mines. The United States had many difficulties in sweeping the area for the following reasons: first, the possibility of encountering numerous mines was not fully appreciated far enough in advance, and MCM forces were given only ten days to do the job. Second, intelligence information on the types and number of mines was inadequate. Third, the charts and maps of the area were outdated.[25] The commander of the amphibious task force, Rear Admiral Allan E. Smith, sent the following message to Vice Admiral Turner C. Joy, Commander Naval Forces Far East, "The U.S. Navy has lost command of the sea in Korean waters."[26]

Vice Admiral Joy summed up the value of mine warfare with the following conclusion:

> The main lesson of the Wonsan Operation is that no so-called subsidiary branch of the naval service, such as mine warfare, should ever be neglected or related to such a minor role in the future.[27]

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[24]Kelso, Frank B. II., CNO, "Meeting The Challenges of an Uncertain World," Mine Warfare Plan, 29 January 1992, p. 18.

[25]Hartmann, p. 78.

[26]Hartmann, p. 78.

[27]Cagle, M.W. and Manson, F.A., p. 136.

A mix of 1904 and 1908 Russian vintage mines claimed 92 lives, sank and damaged several minesweepers, and kept 50,000 men and a 250 ship amphibious force stalled until vital sea lanes were cleared.[28] This was done by "a nation without a navy, using pre-World War I weapons, laid by vessels that were utilized at the time of the birth of Christ."[29]

F. VIETNAM WAR

1. Haiphong Harbor

On 8 May 1972, attack aircraft from the USS *Coral Sea* (CVA-43) dropped 36 magnetic-acoustic mines in Haiphong harbor. The raid lasted only two minutes, but all shipping was stopped immediately.[30] The raid was followed by the airborne mining of North Vietnam's coast and harbors with the intent of pressuring Hanoi to negotiate an end to the Vietnam War. According to Kissenger, "The decision was based, in part, on the recognition of the high leverage but low confrontational risk the action would have."[31] President Nixon ordered the re-mining of the harbor as negotiations in Paris for the release of American prisoners of war stalled. The results were dramatic: none of the nations trading with Hanoi risked steaming their merchant ships into the American minefields. Also, the mining campaign, in conjunction with air attacks against North Vietnam's land lines of communication, severely curtailed the supply of vital munitions to North Vietnam's "Easter Offensive."

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[28]Melia, p. 78.

[29]Admiral Sherman, CNO, summation of the dilemma facing the U.S. Navy in 1950, cited from Melia, p. 151.

[30]The international acceptance of the U.S. mine blockade of Haiphong Harbor during the Vietnam conflict has established a legal precedent for such mine blockades. In that instance, it was argued effectively that all significant requirements for a blockade were established.

[31]Kissenger, Henry, White House Years, 1979, p. 1179.

Strategically and tactically, the mining campaign was a tremendous success, but equally important to the U.S. planners were the lessons learned from the arduous minesweeping operation, named "Operation End Sweep." Operation End Sweep proved that minesweeping, either by aircraft or by surface ship, was not by itself the answer to the tedious task of clearing mines. If a similar situation were to arise today, a RECO capability would alleviate the arduous job of sweeping the minefield by simply turning the minefield off or self-destructing it.

G. DESERT STORM

1. Persian Gulf War

The Iraqi Navy's use of mines during the Gulf War is an excellent case of an inferior navy mounting a credible threat against a vastly superior opponent. By conducting a well-planned, although poorly executed, mining operation, the Iraqis turned their mining campaign into a strategic advantage. Not only did they effectively protect their seaward flank against planned amphibious assaults, but they also won a public relations victory of sorts by damaging two U.S. Navy combatants.

February 18, 1991, brought a graphic example of the damage potential associated with a mine strike. The USS *Tripoli* (LPH-10) became Desert Storm's first mine victim, when she struck a LUGM-145 "cheeseburger" style mine. *Tripoli* lost one-third of her JP-5 fuel, and flooded over 271,000 gallons of water. The mine blew a gaping 20 x 16ft hole in her hull, costing $4 million dollars to repair. The USS *Princeton* became the next mine victim on the same day, when she detonated a 375 lb Italian-made Manta magnetic-acoustic influence mine. The damage to the *Princeton* was estimated at over $15 million dollars and she spent the remainder of the war being repaired.

The U.S. fleet that concentrated for Desert Storm ultimately numbered more than 160 ships, i.e., the largest force deployed since World War II. Six carrier battle groups, two battleship surface action groups, four amphibious groups, numerous surface combatant escorts, and 13 submarines were employed to help defeat Saddam Hussein. Of the more than 540,000 American troops, only 700 (0.13 percent) were naval MCM

forces. An equally astonishing fact is that "more than 90 percent of everything that went to Saudi Arabia and the Kuwaiti theater of operations went by surface vessel."[32] This amplifies the critical need for an increased emphasis on U.S. mine warfare strategy and tactics. The mine threat was not only verified by Desert Storm observations, but was found to be greater than initially anticipated in terms of the toughness, sophistication, and quantities of the mines and obstacles deployed by Iraq. The only factors that prevented U.S. casualties of tragic proportion were the poor quality and unreliability of the majority of Iraqi mines; and the decision to forego the amphibious assault.[33]

H. LESSONS RE-LEARNED FROM DESERT STORM

In November of 1991, then Secretary of the Navy, H. Lawrence Garrett stated:

> ...The Persian Gulf has taught us more than a couple of lessons recently about our neglect. As we operate more and more in confined, coastal waters, and as scenarios requiring over-the-horizon amphibious assaults become more probable, we will be confronted increasingly with cheap and widely available mines. I, for one, have no intention of seeing the Navy someday forced to tell the President that we can't do the job because we're unable to defeat the enemy's mines.[34]

While General Schwarzkopf's unwillingness to permit an amphibious landing revealed shortcomings in shallow water MCM, Desert Storm also illustrated the lack of an effective offensive MCM strategy, as two frontline surface ships were seriously damaged by mines that were laid freely by the Iraqis. The USS *Princeton* and the USS *Tripoli* incidents echoed the Navy's worst experience of the 1987-88 Persian Gulf conflict

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[32]Kelso, Frank B. II., CNO, "The United States in Desert Shield/Desert Storm," 15 May 1991, pp. 28-30.

[33]Naval Research Advisory Committee Report (NRAC), "Countermine Capabilities for Amphibious Operations (Phase II)," Jan 1992, p. 9.

[34]Garrett, H. Lawrence III., Remarks to the Surface Navy Association, 6 November 1991, cited in Melia, p. 129.

(Operation Earnest Will), when the USS *Samuel B. Roberts* (FFG-58) was nearly sunk by a mine.

Mine countermeasures operations in the Persian Gulf were carried out by the ships and aircraft of Belgium, France, Germany, Italy, Japan, The Netherlands, the United Kingdom, as well as the United States. Although, a relatively small number of mines was planted in the Persian Gulf, it was more than enough to inflict serious psychological and physical damage to two U.S. ships, and force the United States to change its tactical battle plans. The USS Princeton and USS Tripoli incidents demonstrated the cost of an inadequate mine warfare strategy. In addition, according to Navy officials, inadequate intelligence information regarding the extent of Iraqi mining in the Gulf and the danger it presented, forced 117 ships to anchor at Fujairah, United Arab Emirates, unwilling to sail further in the Gulf due to concern about mines.[35]

On 12 June 1991, Supreme Allied Commander of Operation Desert Storm, General Norman Schartzkopf, had the following to say to the Senate Armed Service Committee when asked about the value of mine warfare during the Persian Gulf War:

> It had a serious impact on our capability to conduct certain types of operations, and that's the capability that we just must have in the future if we are going to conduct amphibious operations.

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[35]Galatowitsch, Sheila, "Undersea Mines Grow Smarter and Deadlier," Defence Electronics, March 1991, p. 57.

I. SUMMARY

This chapter illustrates the significance a minefield, or the threat of one, has had on naval battles throughout history. The United States has been a victim of many mine warfare lessons of the past, but has failed to fully acknowledge its shortcomings.

Mine warfare improvement plans have repeatedly been published in recent years, but "few have been fully carried out, or significantly bartered away over time."[36] An attempt at remedying the mine warfare dilemma is depicted in the 1994-95 U.S. Navy Mine Warfare Plan, which includes:

1) developing a clandestine mine surveillance, reconnaissance, and detection capability, to detect the numerous "indicators" that an aggressor displays prior to the employment of mines. This is the top priority, and at the core of effective offensive MCM.
2) developing an all-source intelligence data base that will monitor ongoing mine research, development, and technologies throughout the world.
3) developing a command-control-communications-computers and intelligence (C4I) capability.
4) integrating mine warfare with amphibious warfare.
5) developing naval mines and the doctrine and tactics for their use in offensive and defensive operations in future conflicts.[37]

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[36]Melia, Tamara M., "Mine Warfare Languishing," The Navy Times, 15 November 1993, p. 30.

[37]1994 Mine Warfare Plan, p. 25.

IV. THE PROLIFERATION OF MINES AND MINE TECHNOLOGY[38]

A. INTRODUCTION

This chapter focuses on the technological advances mines have made over the past few years, as well as the threat associated with the proliferation of mines and mine technology. Included in this chapter is a list of the countries that are known to make and or export mines. An list of the companies that make up the mine industry is included to give an appreciation for the wide spread corporate involvement. Also, the proliferation of mine technology, which can make a mine "look" different to countermeasure forces, has complicating the already arduous task of clearing a minefield. As the world wrestles with the problem of controlling the proliferation of mines and mine technologies, the United States must pursue its own strategic measures to deter the threat of mines in future conflicts.

B. THE PROBLEM

The reorientation of the U.S. National Military Strategy from global to regional conflict and the concurrent shift of U.S. naval doctrine from open ocean to littoral warfare substantially increased the importance of amphibious operations and mine warfare in relation to other warfare areas.[39] Mines have been the weapon of choice for many developing countries and may, in a regional context, prove to be the ultimate conventional deterrent. The problem facing the United States is that the proliferation of mines and

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[38]Much of the information and analysis contained in this chapter, relating to the proliferation of mines and mine technology was obtained in part from a unclassified thesis done by Daniel M. Green, LT, USN, at the Naval Postgraduate School, December 1993, entitled, Monitoring Technology Proliferation: An Open Source Methodology for Generating Proliferation Intelligence, pp. 68-84.

[39]Department of the Navy, ...From the Sea: Preparing the Naval Service for the 21st Century, September 1992.

mine technologies is advancing rapidly, and mine countermeasures technology simply has not kept pace.

Underwater mines and associated technology have traditionally been very slow to develop and even slower to become obsolete. Contact mine technology that developed at the turn of the 20th century will still be a viable threat in the 21st century.[40] The current weapon inventories of many Third World countries consist of mines produced shortly after World War II.[41] A review of high-tech applications currently being incorporated into mines, however, indicates that mines are rapidly evolving into sophisticated weapon systems. Microprocessors, sonar systems, non-metallic construction materials, unique architectural designs, absorptive coatings, advanced sensors, anti-swimmer devices, remote actuation, and propulsion and guidance systems are being incorporated into the newest generations of mines.

A related technological development of particular concern to those decision makers responsible for evaluating specific regional threats, is the introduction of modular upgrade kits that can be retrofitted to existing mine warstocks. These kits replace a mine's firing circuits with modern electronics, turning relatively simple underwater ordnance into computer controlled, multiple sensor "smart" weapons.

The ability to retrofit existing warstock mines with a microprocessing "brain" has several major implications for mine and littoral warfare. First, force packages and strategies used to counter mines depend on the type (bottom or moored), and the activation device (magnetic, acoustic, or pressure). And secondly, the external identification of the mine is no longer a valid indicator of a mine's capabilities.[42]

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[40]In 1987 and 1988 respectively, the U.S. flagged oil tanker Bridgeton and the USS Samuel B. Roberts struck contact mines that were of pre-World War I design (Mk08).

[41]Jane's Underwater Warfare Systems 1993-1994, Jane's Information Group Ltd., 1993, p. 170.

[42]1994 Mine Warfare Plan, 1992, p. 31.

These upgrade kits are a potential risk because they are currently being offered for export by several companies on the international market. Therefore, previously purchased unsophisticated mines have the capability of being technologically upgraded. Even contact mines can be upgraded with simple kits that transform the mine into a multiple sensor device.

1. The Mine Market

For the purpose of this study, the 1994-95 Mine Warfare Plan is used to highlight the areas of mine warfare that need immediate attention.

The Mine Warfare Plan approaches the threat posed by underwater mine proliferation from the aspect of national mine production and export activity. It states that "currently, 48 world navies are estimated to have some degree of mine warfare capability, 27 countries have a mine manufacturing capability and 20 are known exporters of naval mines."[43] The 1992 Mine Warfare Plan offers a thorough listing of mine producing countries, although, only 16 countries that produce mines are cited. These countries are listed in Table 1.

CHILE	NORTH KOREA
CHINA	RUSSIA
DENMARK	SOUTH AFRICA
FRANCE	SPAIN
GERMANY	SWEDEN
IRAQ	TAIWAN
ITALY	UNITED KINGDOM
JAPAN	YUGOSLAVIA

Table 1: Mine Producing Countries (Source: 1992 Mine Warfare Plan)

[43] 1994 Mine Warfare Plan, p. 21.

An interesting note is that 11 of the 16 nations are either allies or friends with the United States. Of the others, one (Yugoslavia), no longer exists as a nation-state, two (Russia and China), have improving relations with the United States, and another (Iraq), is currently controlled by United Nations sanctions and restrictions. At this time there is only one country, North Korea, that produces mines and is hostile to the United States.

By including non-enemies in this analysis, the Mine Warfare Plan highlights one of the unique aspects of a post-Cold War threat evaluation. The national security establishment can no longer focus on potentially hostile nations exclusively but most contend with potentially hostile environments. Any actor operating in this environment must be considered a potential threat.

Based on the assumption that proliferation is primarily a function of corporate not government activity, several companies were determined to make up the mine industry. The following companies are advertised producers of naval mines and parts or have been involved in some form of underwater mine production during the ten year period 1983-1993. (See Appendix B). Compiling lists of companies is one way of evaluating the threat posed by the proliferation of mines and their associated technologies. More importantly, it emphasizes the growing threat posed by all types of mines.

C. SUMMARY

Mines are a low cost, conventional deterrent that may prove decisive to the outcome of limited regional or littoral warfare. The ability to upgrade existing warstock mines to microprocessor controlled, multiple sensor, "smart weapon" systems significantly alters the strategy used to plan certain military operations. Therefore, accurate intelligence gathering measures to track mine proliferation and technologies are essential to a successful MCM strategy. Intelligence gathering must concentrate on "threat technologies," i.e., those technologies that directly challenge the superiority of existing military weapons and systems. Underwater mine upgrade kits are an example of high technology that enhance the sophistication of a mine and reaffirm the vital importance of possessing a U.S. mine warfare strategy centered around "pro-active" tactics.

V. THE ART OF MINE WARFARE

> Clearly, our ability to conduct effective mine countermeasures and to employ mines when it is in our interest to do so will be critical for the success of future naval operations.[44]
>
> Admiral Frank B. Kelso II
> Chief of Naval Operations

A. INTRODUCTION

This chapter examines the strategic advantages and disadvantages of an integrated offensive mining and mine defense strategy. Specifically, it is proposed that the U.S. Navy exploit RECO capabilities and embrace a pro-active, offensive MCM strategy, the objective being the deterrence of enemy mine laying and hence the security of U.S. control of the sea.

B. THE CONCEPT

Mining is not a "stand-alone" strategy, but one that is most effective when used in conjunction with other strategic and tactical operations. An offensive minefield can be deployed in an area of high tensions, prior to or during hostilities that could force the enemy to make one or all of the following decisions:

1) mount an extensive, time consuming effort to clear the minefield;
2) challenge the field and accept the casualties; and
3) use the waters which are "believed" to be clear of the mines.

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[44]Kelso, Frank B. II., CNO, "Building Blocks of Naval Power," Proceedings, November 1992, p. 44.

1. The Advantages of Mining

Stress and uncertainty lie at the heart of mine warfare. In the past, the psychological impact of a minefield has often overshadowed its physical threat. The mine's value lies not just in the damage it inflicts on shipping, but also in the fact that the suspected presence of a minefield can suffice to bring shipping to a halt. Operators need to be reasonably certain that it is safe for shipping to move. Therefore, the psychological damage is quite often the greatest gain of a mining effort. The minesweeping effort necessary for "safe" passage can create important strategic delays. Insurance companies increase premiums to cover the added risk, and crewman balk at sailing in waters that may be mined. The recent technological advances in mines have made it extremely difficult to provide reasonable assurances of safe passage.

Minefields are like twilight zones - they work more on human minds than on the ships themselves. As Bartholomew and Greer put it: "We must use our knowledge and exaggerated fears of the unknown to our advantage, and explore mine warfare's full psychological potential."[45] The mine's ability to create fear of the unknown is generally overlooked by naval officers and planners. Instead, the number of disabled ships is commonly cited as the indicator of the weapon's effectiveness. Yet, less obvious but equally decisive in the outcome of battles are all the ships that never went in harm's way, never became disabled, and never contributed to disabling anything else. The more a minefield controls a ship's movement, the greater the minefield's effectiveness.

The psychological threat of a minefield can be strategically significant. Its success is not necessarily measured by the number of enemy ships sunk, but rather by the constraining impact it has on enemy plans and movements. A minefield is successful if enemy ships are delayed, diverted, or kept from using strategically significant bodies of water. Minefields achieve that goal principally through the opponent's perception of the threat they pose to his shipping. The fact that mines can sink ships makes their threat

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[45]Bartholomew, James and Greer, William., "The Psychology of Mine Warfare," Proceedings, February 1986, p. 58.

credible. But the real effect of a minefield comes from the more subtle influence of an exaggerated fear. This may be true for other weapons as well, but it is especially so for mines.

The psychological threat of the mine emanates from the uncertainty it creates and, secondly, from the fear of the dire consequences if the threat proves to be underrated. Minefields are unique in the fact that they cannot be engaged in combat like other enemy forces. A minefield lies quietly, revealing itself only when engaged. The detonation of one mine gives no assurance that the field is clear of danger and gives virtually no information about the presence of other mines. If anything, it confirms the presence of a "hidden threat." Mining is distinguished from other naval operations in that it frequently offers an opportunity to inflict severe long-term damage on the enemy while affording little or no chance of retaliatory action against attacking forces. Minefields offer the unique possibility of setting up a preemptive defense in which the aggressor must take full responsibility for the casualties he suffers. Mining permits enemy shipping to be attacked without the necessity for the delivery vehicle to engage or even to locate the target, so that the smallest minelayer may indirectly destroy the most powerful warships. The mine may also offer the advantage of covertness and surprise; the first indication of its presence may be detonation. Even if not covert, mining offers the advantage of concealment; it offers no visible warning of danger, and its exact location is for all practical purposes unknown.

Naval mines, whether used offensively or defensively have the following unique characteristics:

1) they are relatively cheap weapons, typically costing less than $20,000;
2) they are universal weapons that are easy to acquire on the world's arms market. The same is true for mine "upgrade" kits;
3) they are clandestine weapons that incite terror and intimidation;
4) they are weapons that wait and pose little return threat to the mine layer;
5) they are passive weapons that can cause an enemy to change his tactics;

6) they are a constraining weapon, so that enemy shipping may be attacked more easily by other weapons;

7) they can delay naval operations;

8) they are a continuing menace to moral, and their psychological attributes may be subtle, but are not taken lightly by commanders and decision makers who evaluate the associated risks involved;

9) they offer warfighting leverage, they are force multipliers that produce significant advantages as "trump cards."[46]

C. OFFENSIVE MINING: A VIABLE ALTERNATIVE FOR THE FUTURE

Offensive minefields are planted in enemy controlled or in disputed waters. Under certain circumstances, offensive mining in massive numbers early in a conflict may disrupt an enemy's ability to execute his war plans, more effectively than any other naval weapon. Also, the use of mines to constrain enemy ships in safe waters would make the latter more susceptible to attack by other forces. A long-term advantages of offensive mining is the fact that after successful mining has been achieved, either in previous conflict or the present conflict, the simple threat of mining may be all that is necessary to achieve effective results.

The U.S. Navy used limited offensive mining during Desert Storm in the hope of isolating Iraqi naval vessels, predominantly fast patrol craft, at their bases. A single mining mission was conducted at the mouth of the Khawr Az-Zubayr River, a choke-point through which most of the Iraqi Navy would have to pass on its way to the Gulf. The strike involved a total of 18 carrier aircraft, with four A-6E's laying 42 MK 36 mines (six others failed to release from an aircraft) at the expense of one A-6E.[47] The operation was not a critical factor in the Navy's success during Operation Desert Storm, although a

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[46]1992 Mine Warfare Plan, p. 29.

[47]Department of Defense, "Conduct of the Persian Gulf War," April 1992, pp. 193-194.

offensive mining campaign aimed at preventing the Iraqi's from laying mines in the early phases of the conflict might have brought different results.

D. REMOTE CONTROLLED (RECO) MINES

RECO mines offer the United States a political bargaining advantage as well as a tactical naval advantage that is truly unique. Controlled mines are not new perse. In 1878, with the help of Army engineering General, H.L. Abbot, the United States was the first to designed the remote control mine, specifically for the defense of harbors. The mines were primitive in comparison with today's standards, consisting of buoyant steel cases containing between 25 and 500 pounds of explosives. Each mine had a "hot" wire detonator and an electrical cable that attached to a battery on shore. A system of mines consisted of 5 to 10 mines whose individual cables were connected to a junction box from which a single multiple conductor cable was placed on shore. The main problems with controlled mines in those days were its unreliability and the difficulty of determining from a shore station when the enemy was within the damage range.[48]

Modern controlled mines no longer rely on hard wiring to a nearby shore station. Their activation depends instead on the receipt of a coded Very Low Frequency (VLF) signal. VLF is currently the only satisfactory means of long-range underwater communications in deep water.[49] Even so, the effective transmission of a coded VLF message remains the major obstacle facing the development of a operational RECO mining capability. Preliminary study indicates that an acoustically coded sonar "ping" is probably the most reliable and easiest way of transmitting a code. Although the coded

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[48]Duncan, Robert, C., America's Use of Sea Mines, 1962, p. 33.

[49]Watts, Anthony J., Jane's Underwater Warfare Systems, Sixth Edition, 1994-1995, Jane's Information Group Limited, p. 138.

message to a mine could conceivably be intercepted, its complexity makes it virtually impossible for an opponent to duplicate it and engage in remote "countermining."[50]

1. Advantages of Remote Controlled Mines

The placement of inactive RECO minefields prior to hostilities can overcome some of the difficulties inherent in commencing "conventional" minelaying operations after hostilities have commenced. An example of these difficulties are: first, the lack of available minelaying assets because of higher priority needs, second, attacks on those assets, and third, the possibility that enemy submarines may have been predeployed prior to commencement of hostilities. The most attractive advantage of RECO is that they may be emplaced in international waters beyond the territorial sea subject only to the requirement that they do not unreasonably interfere with other lawful uses of the oceans. The determination of what constitutes an "unreasonable interference" involves a number of factors which include: the rationale for their emplacement, extent of the area to be mined, the hazard to other lawful ocean uses, and the duration of their emplacement.[51] All factors that RECO could justify in a strategy aimed at deterrence. Because remote controlled mines do not constitute a hazard to navigation, international notice of their emplacement is not required.[52]

RECO mines would allow the U.S to de-escalate from a highly threatening posture by simply turning them off. Thereby, eliminating the requirement to sterilize or scuttle extremely expensive minefields. This could also prove to be an effective deterrent if an opponent had ideas of re-escalating a conflict.

The preemptive deployment of RECO mines can also be used to deter an opponent from initiating a mining campaign. If an opponent were to use another nation to aid in

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[50]Telephone interview with Victor Newton, a mine expert from the Coastal System Station at the Naval Surface Warfare Center in Silver Springs, MD, 21 November 1994.

[51]NWP 9, Chapter 9, Paragraph 9.2.2, p. 9-5.

[52]NWP 9, p. 9-5, emphasis added.

mine laying operations, RECO could be used as a "blockade" to restrict the flow of shipping to a given port, thus denying the opponent economic exchange. Offensive mining with RECO mines would not only give the United States a tactical advantage if forces are to be projected ashore, but would also convey U.S. resolve in a situation while avoiding the active use of military force. The ability to turn a minefield on or off could give the United States an added strategic advantage which may be especially useful at an early stage of a conflict. Because the evolution and termination of a conflict is often uncertain, the conventionally armed mines may not be laid in time (due to the "other" priority requirements of available assets during a crisis) to achieve their full effect, especially since the delayed activation and scuttling features of the mine need to be preset. RECO can solve this dilemma by deferring these requirements until the decision whether or not to arm is made.

For a relatively modest investment in research and development funds, various types of remote control could be developed and tested to the maximum safety standards. The technology was proven effective in the 1980s by White Oak Mine Laboratory, and by increasing funding, as shown in Table 2 below, the United States could have RECO capability available in FY98.

Appropriations	FY94	FY95	FY96	FY97	FY98	FY99
RDT&E	3.5	9.0	15.0	3.0	0	0
Other Procurement, Navy	-	-	-	5.0	10.0	10.0
Quantity	-	-	-	300	700	700

* ALL NUMBERS IN MILLIONS

Table 2: Funding Required for RECO (Source: Mine Warfare / EOD Branch)

2. Disadvantages of Remote Controlled Mines

The laying of "inactive" RECO mines in the high seas during periods of increased tension could possibly escalate the level of tension in certain situations, although it would set a long term precedent for future adversaries to consider prior to initiating a mining campaign. Also, mining with "unarmed" mines prior to hostilities could possibly incur protests from the maritime community because of the fear associated with inadvertent actuation.

E. IDENTIFICATION FRIEND OF FOE FOR MINEFIELDS (IFFM)

IFFM is a beneficial, although not an essential, ingredient for the offensive minefields of the future. Its primary benefit is that it will safeguard friendly shipping that ventures into the minefield, whether accidentally or because of tactical necessity. The technology involved is conceptually similar to that used by aircraft, and basically enables the mine to "look" at a passing ship and determine whether it is friendly or foe. IFFM would be beneficial in the following situations:

1) navigation and maneuver problems that may arise from operational constraints or simply mechanical difficulties.
2) if tactically necessary, it will allow a friendly ship or submarine to sail into a friendly minefield without setting off the mines.
3) its primary purpose is to enhance platform maneuver safety in the vicinity of own minefields.

IFFM is intended for combatants as an additional safeguard that will also facilitate mining. The one-on-one interrogation of IFFM provides a ship with real-time maneuvering freedom. A prerequisite is that the platform be equipped with an IFFM transponder or transmitter whose emitting signal or "squawk" will tell the mine whether the passing ship is friend or foe.

1. IFFM Tagging

"Tagging" enemy ships to emit a foe-code is a system design option for IFFM that has been studied as an alternative to U.S. ships emitting a friend-code.[53] Using this option, the mines will only fire on transistors that emit a foe-code. Obviously, the extent of successful mining using foe-code IFFM will depend on the ability to tag the foe ahead of time. It may be possible to covertly tag a number of clearly identifiable platforms, such as enemy submarines, but a large-scale tagging operation would probably not be practical.

F. GENERIC MINING SITUATIONS[54]

The following "scenarios" suggest how a RECO mine capability, combined with IFFM, may be tactically used to deter or combat an opponent.

1. Deferred Activation and Early Termination

While current mines can be set for an active time cycle using delayed activation and eventual deactivation, a decision about the timing must be made before the mines are made ready for planting. Uncertainty about when to de-activate can hamper the effective use of mines, and prevent them from being used as a viable option.

On the other hand, RECO can turn the minefield on or off when desired thereby removing reservations about laying mines that stem from uncertainties about the development of the conflict and the movement of U.S. platforms. RECO, therefore, has strategic implications because it allows the Navy to benefit from the potentially high

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[53]Dence, W., "Report on Possible Implementation Schemes for IFF for Minefields (IFFM)," Naval Surface Warfare Center, Dahlgren Division, Memorandum, 21 Oct 1992.

[54]The following "Generic Mining Situations" were studied by the Surface ASW and Mines Analysis Office of the Warfare Analysis Department at the Naval Surface Warfare Center, Dahlgren Division. This report documents an assessment made in support of Mine Warfare Block research of implementation schemes for Identification Friend or Foe (IFF) for minefields. The assessment was sponsored by the Office of Naval Research (ONR-T 4533).

political and military utility of mines in situations where other means may be too aggressive and where the lack of a RECO capability might preclude the use of mines altogether. An obvious tactical benefit of RECO is that the mines can be laid to accommodate the availability; and the activation of a minefield can be deferred until a decision to do so is made.

The need to lay the mines covertly is another mission requirement that RECO can meet because of the lead time this capability provides a battle group commander in choosing a platform and the time frame, which best suit his operational requirements.

Typically, a period of increased tensions proceeds the outbreak of hostilities, and during this period a peaceful settlement through diplomatic negotiations is still a possibility. However, in order to prepare for the eventuality of war, as well as to back up the negotiations, forces and supplies may be required to be lifted to the area. During this vulnerable build-up period, the arriving reinforcements and supplies must be protected. Defensive RECO minefields can serve as one form of self-protection.

At the conclusion of a conflict, when the United States must clear its own mines, RECO can be highly useful in not only protecting MCM forces, but also in detonating the mines if needed. IFFM could also be used to re-locate the mines for future use. In Vietnam, the Navy was eventually tasked with clearing thousands of mines in Haiphong harbor, an operation that ultimately, because of the loss of two helicopters, cost about twice as much as laying the mines.[55] In the future, an alternative method of clearing U.S. mines is extremely important for the simple fact that it eliminates any risk to U.S. forces.

2. Flank Protection Mining

Flank mining, i.e., the protection of a given area or forcing an enemy into an area that is strategically advantageous to the United States, can also include traffic channelization and Amphibious Objective Area (AOA) protection. The ultimate objective of these types of mining operations is the protection of U.S. traffic and military operations

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[55]Kelso, Frank B. II., CNO, "Building Blocks of Naval Power," Proceedings, November 1992, p. 41.

from hostile platforms. Flank mining can channel merchant traffic to check points that allow U.S. platforms to intercept enemy submarines and surface combatants, and in effect, gain the tactical advantage. The five month build-up of allied forces prior to the Gulf War is suggestive of how minefields could have been useful in protecting the local Sea Lanes Of Communication (SLOC), especially if the threat had included submarines.

Minefields for flank protection are most effective when they put a threat platform beyond its tactically useful range of operations. The separation must also leave space for friendly ASW operations between the minefield and the SLOC channel in case enemy platforms penetrate. The mines must be laid so as to preclude blue-on-blue (friendly) encounters, so that the ships can operate within their bounds. The possible situations that could place U.S. ships near the mines are:

1) faulty navigation;

2) maneuver problems;

3) drifting to minimize noise;

4) taking up flank station for air defense; and

5) chasing enemy surface or subsurface platforms

In February 1991, the USS *Princeton* (CG-59) and the USS *Tripoli* (LPH-10) were damaged by Iraqi mines while on station off the coast of Kuwait. The USS *Princeton* carried the AAW Commander for an MCM task group and continued to operate in the area after receiving U.S. intelligence estimates about Iraqi minefields.[56] This clearly demonstrates that the Navy is ready to accept mine related risks in order to succeed in its mission. It is clear that U.S. ships, on occasion, may not have the option of staying well clear of U.S. mines, and uncertainty about the location of the mines will undoubtedly complicate the decision of pursuing the mission. Although, it is obviously tragic to hit

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[56]Melia, pp. 128-129.

a mine, it is especially so if one's own mine is the culprit. In such situations, IFFM would significantly lower this risk.

3. Port and Naval Base Closure Mining

This mission is clearly offensive and would probably not be utilized until after a conflict has begun. In the Persian Gulf War, the United States mined the Iraqi port and naval base at Umm Qasr a few days after the shooting war began.[57] A benefit of closing down a port with mines instead of bombing the port facilities is that it not only leaves the port intact but is a far more humanitarian and cost-effective solution. RECO would make it possible for U.S. ships to enter the port without having to wait for the mines to be cleared. The U.S. could then immediately use the port for strategic purposes or to bring in its own supplies in order to conduct relief operations, etc. IFFM would act as an added safety feature for those ships configured with it.

4. Coastal Water ASW Mining

The threat posed by coastal submarines and the unpredictable acoustic conditions in shallow waters combine to make mines a potentially effective complement to enemy surface and submarine forces. By stretching minelines seaward from the shoreline, enemy submarines hugging the coast would be intercepted or forced out into deeper waters where other U.S. forces could better prosecute them. With the employment of this tactic, IFFM would be highly useful in allowing U.S. platforms the option of chasing or luring the enemy into the minefield.

G. OFFENSIVE MINING SUMMARY

It appears, based on a qualitative assessment of projected benefits and limitations, that RECO and IFFM while overlapping somewhat have significantly different implications. RECO may be more significant in enabling mining to be employed and IFFM has its greatest utility in safeguarding friendly ships operating close to their own

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[57]Kelso, Frank. B. II., CNO, "Building Blocks of Naval Power," Proceedings, November 1992, p. 41.

mines. Therefore, IFFM can also facilitate tactical mining. The operationally ideal solution, from a strategic as well as safety standpoint, would be a combination of the two.

The U.S. Navy learned some valuable mine warfare lessons from Desert Storm, although the actual funding required to remedy these problems has taken a back-seat to more "important" programs. The Navy has been especially delinquent with respect to its rapidly dwindling mining capabilities.[58]

> Given the high leverage that offensive and defensive mining provides, it is surprising that there are no mine development programs ongoing in the U.S. Navy.[59]

Although all three of the Navy's warfare "communities" (surface, air, subsurface) have a mine laying capability, none has embraced the mine as its "own." Of the money appropriated to mining programs - which represents less than 1% of the Navy's total obligated authority - offensive mine programs receive less than 10% of mine warfare funding, while less than 2% is invested in mine research and development.[60]

Warfare in regional conflicts requires systems that, besides producing the necessary threat, also produce the flexibility needed when a battle plan shifts and the political and operational direction of a conflict changes. This has been the case in recent conflicts and will undoubtedly be the case in future littoral warfare. Therefore, the

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[58]This point was emphasized by Edward Zdankiewicz, Deputy Assistant Secretary of the Navy (Mine and Undersea Warfare), during a September 1993 briefing to a National Security Industrial Association Mine Warfare Conference, cited in Proceedings, October 1994, p. 44.

[59]Keller, Stephen H., "What Weapons That Wait," Proceedings, October 1994, p. 44.

[60]Keller, p. 44.

capability to control U.S. minefields and assure safe shipping passage by turning whole segments on or off, will be strategically significant in future mine related conflicts.

H. OFFENSIVE "PRO-ACTIVE" MINE COUNTERMEASURES

There exist several methods that the Unites States could employ to more effectively prevent an aggressor from laying mines before and during a conflict. Ultimately, if the United States can successfully prevent an aggressor from laying mines, it will eventually deter these acts of aggression from taking place. The following methods illustrate how accurate intelligence gathering, coupled with a strong U.S. policy, can signal resolve.

1. Deterrence

The mission of all U.S. military forces is to deter aggression and, should deterrence fail, to engage and defeat the aggressor in armed conflict so as to restore international peace and security. In order to deter aggression, U.S. military forces must be both capable and ready, and must be perceived to be so by potential aggressors. Equally important is the perception of other nations that, should the need arise, the U.S. has the will to use its forces in individual or collective self-defense.[61]

Deterrence is a "state-of-mind" brought about by a credible threat of retaliation and the deterree's conviction that the action being contemplated cannot succeed, or his belief that the costs of the action will exceed any possible gains. Thus, the aggressor is reluctant to act for fear of failure, costs, or both. The presence of naval forces to a crisis area is one of the strongest deterrent signals the United States can send. It is are unequivocal evidence that a fully combat-ready force stands poised to protect U.S. national interests. If the United States is not able to effectively deter an aggressor, or if an aggressor questions U.S. resolve in a given situation, that resolve may be displayed through the use of force, thus pushing the United States into military action.

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[61]National Security Strategy of the United States, The White House, January 1988, pp. 3-4 and 13-14, cited in NWP 9, p. 4-7.

> Deterrence...does not exist in abstract isolation; it arises from a hypothesis, however conditional or remote, of actual use.[62]

If a mine threat were to arise, the United States must be ready to deter it. In support of the principle that aggression will not pay, U.S. military forces may have to be used and they must be ready to undertake the effort quickly and successfully. Though no one cannot predict or stop all uses of force, the United States can effectively deter most. The price of being able to do that - the price of deterrence - is political will, credible military capabilities, and constant vigilance. The United States can no longer afford to react to an aggressor's use of mines. Instead, it must aggressively pursue strategic and tactical alternatives that deter the enemy from using mines. After all, the only really effective counter to mines is their prevention.

2. Attacking the Problem

An excellent example of a truly "pro-active" strategy was seen during the 1987-88 Iran-Iraq war in the Persian Gulf. Despite the protests from Iran that its vessels were not laying mines, U.S. intelligence assets tracked the Iranian landing craft, *Iran Ajr*, from its port in Iran to an area north of Qatar in September 1987. A helicopter from the frigate, USS *Jarrett* (FFG-33), using night-vision cameras, detected minelaying activity aboard the vessel and observed the crew laying at least six mines. It then fired on the ship. After a short time the *Iran Ajr* resumed minelaying, and the helicopter opened fire again. At daybreak a boarding party captured the vessel with nine mines aboard. The publicity surrounding this event effectively halted Iranian minelaying for six months. The boarding party also recovered charts marked with minefields planted that night, allowing MCM forces to clear the field.[63] Intelligence during this war was critical to the successful

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[62]Quinlan, Michael, "Nuclear Weapons and the Abolition of War," Journal of International Affairs, April 1991, p. 31.

[63]Giusti, James R., "Sweeping the Gulf," Surface Warfare, March-April 1988. The contact mines captured aboard the Iranian Ajr may have been Russian supplied from North Korean stock.

interception of the Iranian minelayer, and it allowed the United States to demonstrate an unquestionable commitment to the safe passage of innocent vessels. This is a tactic the United States needs to embrace, not only for the overall security and safe passage of innocent commercial and naval vessels, but in support of U.S. naval operations. The implications of not countering vessels laying mines in international waters could be disastrous. Desert Storm is proof that if a minelayer is allowed to freely lay mines the consequences could be severe.

3. The Use of Special Operations

The employment of special operation forces for intelligence gathering missions could expose many strategic and tactical enemy elements and is one of the most highly valued missions of special operators. The information gathered concerning enemy mine transfers, manufacturing warehouses, logistical infrastructure, and minefield location and type, would be of critical concern to the overall success of U.S. operations.[64]

During the 1987-88 Iran-Iraq War, the United States used the expertise of special operators and staff officers who served on mobile support bases in Vietnam (Joint Task Force Middle East) to transform two mobile oil platforms into Mobile Sea Barges in an effort to prevent minelaying. The Iran-Iraq War proved that the prevention of minelaying is a joint service operation and one of the most important elements of an effective offensive mine countermeasures campaign.

It is impossible to overestimate the importance of timely and accurate intelligence and the contributions special operation forces can make to the overall strategic effectiveness of any operation involving mine warfare. Their capabilities must be utilized before a crisis to fully expose the enemy's mining potential.

4. Intelligence, Surveillance and Reconnaissance

The Navy has initiated a number of intelligence gathering concepts that focus on current operational deficiencies. The Naval Studies Board recently identified three areas that are of the utmost importance to a successful MCM operation. They are:

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[64] 1994 Mine Warfare Plan, p. 26.

1) Intelligence: the activities undertaken by technical collection agencies, beginning in some cases before a mining crisis and continuing beyond the end of a contingency in which mines were used.

2) Surveillance: sensing and reporting of land and sea activities by satellites, manned and unmanned vehicles, and people, and begins before mines are moved from storage sites to minelaying platforms, continuing throughout a crisis/conflict.

3) Reconnaissance: provides the "ground truth" of mines in an area of interest, and contributes to operational and tactical planning.[65]

Mine warfare intelligence, surveillance, and reconnaissance can be enhanced significantly through covert, clandestine operations. The overall value of this information, coupled with technical intelligence data, is enormous, permitting a real-time evaluation of the mine threat.

The Navy has also begun to take steps to integrate attack submarines more completely into mine force planning and operations with the ultimate goal of expanding their capabilities so as to provide surveillance, reconnaissance, and detection of enemy mining activities. The SSNs will be aided in this role by U.S. Navy SEALs. The Air Force and Navy maritime patrol aircraft have also been working together to provide mine warehouse, logistical routes, and storage facility information through photo-intelligence missions.[66] Unfortunately, the availability of resources for timely and effective surveillance remains limited.

I. OFFENSIVE MINE COUNTERMEASURES SUMMARY

The Navy needs to develop and most importantly embrace an aggressive mine countermeasures strategy to prevent the laying of mines. Through a combination of forward basing, surveillance, patrolling, and carefully measured responses to individual

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[65] 1994 Mine Warfare Plan, pp. 47-48.

[66] 1994 Mine Warfare Plan, p. 26.

situations, the United States would signal commitment and a no-nonsense approach to those who challenged its resolve.

Programs such as these paint an attractive picture for the future of mine surveillance and reconnaissance, but the unfortunate reality is this highly sophisticated technology and the employment of air assets are extremely limited, and that more "vital" mission requirements will most probably take precedence in the future. Unfortunately, the fate of a mine warfare operation may well turn on the acquisition of intelligence about enemy mines, warehouse facilities, transporting of mines, and minefields.

> I believe there are some fundamentals about mine warfare that we should not forget. Once mines are laid, they are quite difficult to get rid of. That is not likely to change. It is probably going to get worse, because mines are going to become more sophisticated.[67]
>
> Admiral Frank B. Kelso II, USN
> Chief of Naval Operations
> October 1991

[67] 1994 Mine Warfare Plan, p. 3.

VI. RULES OF ENGAGEMENT

A. INTRODUCTION

This chapter highlights the point that, once "armed" mines are laid the commander of a naval vessel is effectively, under attack. It also points out that the JCS Rules of Engagement (ROE), which govern an on-scene commander's actions, are vague with respect to the ability of the so-threatened ship to defend itself.

U.S. rules of engagement are the means by which the National Command Authorities (NCA) and the U.S. military chain of command authorize subordinate commanders to employ military force for the self-defense of the nation and its citizens, and the protection of national assets worldwide. Rules of engagement delineate the circumstances and limitations under which U.S. naval, ground, and air forces will initiate and / or continue combat engagement with enemy forces.[68] A principle tenet of those ROEs concerns the responsibility of the commander to take all necessary and appropriate action for his unit's self-defense.[69] A commander must have the authority and capability to exercise the inherent right of self-defense. It should be clear that, once an "armed" mine has been placed in international waters, this is done with the intent to inflict casualties (whether physical or psychological).

1. The Right of Self-Defense

The Charter of the United Nations recognizes that all nations enjoy the inherent right of individual and collective self-defense against armed attack. U.S. doctrine on self-defense, set forth in the JCS Peacetime Rules of Engagement for U.S. Forces, provides that the use of force in self-defense against armed attack, or the threat of imminent armed attack, rests upon two elements:

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[68]NWP 9, paragraph 5.5, p. 5-19.

[69]NWP 9, Peacetime Rules of Engagement (ROE), paragraph 5.5.1, p. 5-19.

1) necessity, i.e., the requirement that a use of force be in response to a hostile act or hostile intent; and

2) proportionality, i.e., the requirement that the use of force be in all circumstances limited in intensity, duration, and scope to that which is reasonably required to counter the attack or threat of attack and to ensure the continued safety of U.S. forces.[70]

It should be clear that the laying of "armed" mines in international waters is indeed an armed attack with hostile intent that places any and all those who transit those waters in jeopardy. Defense against a mine-laying aggressor would be permitted within the established guidelines of an act of self-defense and should be permitted by the U.N. Charter.

Included within the inherent right of self-defense is the right of a nation (and its armed forces) to protect itself against imminent attack. International law[71] recognizes that it would be contrary to the purposes of the Charter if a threatened nation were required to absorb an aggressor's initial and potentially crippling first strike before taking military measures necessary to thwart an imminent attack. U.S. Navy Regulations and typical peacetime ROEs authorize an on-scene commander to shoot first when necessary for anticipatory self-defense of forces under his command - for example, to defend against a kamikaze aircraft diving on a ship in sufficient time to ward off the blow. This is known as unit self-defense. A ship is similarly "under attack" when a mine is placed in

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[70]NWP 9, paragraph, 4.3.2.2, p. 4-9.

[71]International law is defined as the body of rules that nations consider binding in their relations with one another. International law derives from the practice of nations in the international arena and from international agreements. International law provides stability in international relations and an expectation that certain acts or omissions will effect predictable consequences. Nations typically comply with international law because it is in their best interest to do so.

international waters. The outcome, if not countered, has the potential of being equally, if not more catastrophic for the ship and crew.

History suggests that conflict will continue to occur in the future and U.S. forces will undoubtedly be called upon to help. Typically, U.S. forces will be inserted by air, but they will most certainly be supported from the sea. Mines, the "poor man's" option, will undoubtedly be used to delay U.S. forces, cause political embarrassment, and most importantly inflict casualties. Each of these objectives, if successful, will tend to restrict U.S. military and political options and ultimately impede on the U.S. ability to project forces ashore.

B. DO U.S. SHIPS HAVE TO TAKE THE FIRST HIT?

Because one mine (or missile) may sink a ship, naval officers must ask themselves whether or not they have to take the first hit before a ship can react in self-defense.

International law, Navy Regulations, and Rules of Engagement permit the use of force during peacetime if necessary for self-defense. The intent in each case is to restrain aggression, to prevent the outbreak of hostilities, and to guard against escalation if shooting does start. There are, however, a few circumstances where shooting first is permitted:

1. Higher Command

Shooting first may be specifically authorized by higher command when necessary for anticipatory self-defense of other U.S. forces, U.S. citizens or its territory. Higher command rejected the use of force, in reality, self-defense, during the Persian Gulf War for fear of an early initiation of the war. The outcome of the failure to engage in anticipatory defense against Iraqi minelayers was costly. Aside from the financial cost of the damage ($4 million for the USS *Tripoli* and $15 million for the USS *Princeton*), both ships were taken out of action at a crucial point of the war. If higher command had embraced an offensive MCM strategy, aimed at deterring Iraqi minelayers, the mine warfare results of Desert Storm might have been quite different.

C. MINES LAID DURING DESERT STORM

Vice Admiral Stanley R. Arthur, the commander of U.S. naval forces in the Persian Gulf, recommended in mid-December 1990, a month before operation Desert Storm, that the Navy begin sinking Iraqi ships that were laying mines at night in international waters off Kuwait. The recommendation was turned down in Washington, and on 18 February, Iraqi mines severely damaged two U.S. warships as they prepared for an amphibious assault to liberate Kuwait. Admiral Arthur, commenting on the interpretation of international law, stated:

> International law makes clear that persons engaged in laying mines in international waters are involved in an act of war. We all understood that. We all say we honor that. But in fact, to my knowledge, in my professional Navy career, we've never gone and sunk a guy laying mines the first shot out of the gun...We always sort of pace around the camp fire. So we sometimes buy ourselves into a problem by not exercising our right.[72]

To underscore his point, Arthur noted that, were an Army commander to open up his tent flap and find somebody planting a land mine outside, he would shoot him.[73] The laying of "armed" mines is in effect, a first strike by an opponent, and it should be treated as such. If an on-scene commander has sufficient intelligence on the laying of such mines in international waters, the reaction from a higher authority should be swift. It has been suggested that the United States failed to target the Iraqi minelayers in the early stages of the conflict for fear that it might trigger Iraqi retaliation against the continuing U.S. military build-up. Nevertheless, by permitting the Iraqi's to continue its mining campaign unhampered the U.S. forces jeopardized its control of the sea, and lost a tactical advantage.

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[72]Arthur, Stanley R., VADM, USN, "Fleet Commander Recommended December Hits on Iraqi Minelayers," Navy Times, 27 May 1992, p. 4.

[73]Arthur, p. 4.

D. SUMMARY

The question that must be asked is this: is the loss of one ship and its crew to a mine strike an "acceptable risk?" And, can the United States afford to alter battle plans and tactics because the area of operations has been mined? If the answer is "No," what measures can the United States take to minimize the potential threat posed by an enemy minelayer? Desert Storm obviously taught the Navy some bitter, but valuable mine warfare lessons in this regard. The question is, whether the United States will institutionalize these lessons learned or retrace the all too familiar path that history has paved?

The United States lost strategic agility in the Persian Gulf War by tacitly allowing the Iraqis to lay mines uncontested in the later months of Desert Shield. If the Iraqis had proven to be a more organized and unified fighting force, the results could have been far more disastrous than they turned out to be.

Carl Von Clausewitz, the 19th Century master of strategy, warned against postponing action (or reaction in this case) to the point where further waiting brings a disadvantage upon a force.

> If the force on hand is not equal to the action contemplated and must wait for reinforcement past the time for action, the benefits of strategic agility are lost. The main feature of an offensive battle is the outflanking or by-passing of the defender - that is, taking the initiative.[74]

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[74]Clausewitz, Carl Von, "On War," edited by Michael Howard and Peter Paret, 1984, p. 530.

VII. A LEGAL ANALYSIS OF MINING

A. INTRODUCTION

This chapter describes how international law, the fundamental rules that nations consider binding in their relations with one another, addresses mining operations in time of peace and war. There are several international agreements which, at first glance, appear to impact the use of mines, however, they are primarily intended to protect neutral vessels and nations. This chapter primarily focuses on RECO mines and how their employment in international waters is within the legal limits of the international law.

B. THE HAGUE CONVENTION

Naval mines have been employed for area denial, coastal and harbor defense, antisurface and antisubmarine warfare, and blockades for years. Naval mines are lawful weapons, but their indiscriminate potential has led to specific regulation of their deployment and employment under the laws of armed conflict. The extensive and uncontrolled use of naval mines by both sides in the Russo-Japanese War of 1904-05 inflicted great damage on innocent shipping both during and long after that conflict, and led to Hague Convention No. VIII of 1907. The purpose of the Hague rules was to ensure, to the extent practicable, the safety of peaceful shipping. They required that naval mines be so constructed as to become harmless should they break loose from their moorings or otherwise cease to be under the affirmative control of the forces who laid them. The Hague rules also required that shipowners be warned of the presence of mines as soon as military conditions permitted.

The convention was scheduled for renewal in 1914, but World War I prevented this, and consequently the stipulations of the original 1907 Hague Convention have never been updated or amended. Technological developments have created weapons systems

obviously not contemplated by the drafters of these rules, but the latter remain, for all practical purposes, the basic international mine warfare pact in force today.[75]

C. PEACETIME MINING

Consistent with the safety of its own citizenry, a nation may emplace both armed and controlled mines in its own internal waters at any time with or without notification. A nation may also mine its own archipelagic waters and territorial sea during peacetime when deemed necessary for national security purposes.[76] If "armed" mines are emplaced in archipelagic waters or the territorial sea, appropriate international notification of the existence and location of such mines is required. Because the right of innocent passage can be suspended only temporarily, armed mines must be removed or rendered harmless as soon as the security threat that prompted their emplacement has terminated. Emplacement of controlled mines in a nation's own archipelagic waters or territorial sea is not subject to such notification or removal requirements.

Armed naval mines may not be emplaced in the internal, territorial, or archipelagic waters of another nation in peacetime without the nation's consent. Controlled mines, however, may be emplaced in international waters beyond the territorial sea subject only to the requirement that they do not unreasonably interfere with other lawful uses of the oceans. The determination of what constitutes an "unreasonable interference" involves a balancing of a number of factors including the rationale for their emplacement (i.e., the self-defense requirements of the emplacing nation), the extent of the area to be mined, the hazard (if any) to other lawful ocean uses, and the duration of their emplacement. Because controlled mines do not constitute a hazard to navigation, international notice of their emplacement is not required.

Armed mines may not be emplaced in international waters prior to the outbreak of armed conflict, except under the most demanding requirements of individual or

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[75]NWP 9, Chapter 9, Paragraph 9.2, p. 9-2.

[76]NWP 9, p. 9-2.

collective self-defense. Should armed mines be emplaced in international waters under such circumstances, prior notification of their location must be provided and the anticipated date of their complete removal must be clearly stated. The nation emplacing armed mines in international waters during peacetime also assumes the responsibility to maintain an on-scene presence in the area sufficient to ensure that appropriate warning is provided to ships approaching the danger area. All armed mines must be expeditiously removed or rendered harmless when the imminent danger that prompted their emplacement has passed.

D. LEGALITY OF REMOTE CONTROLLED MINES

Remote controlled mines greatly enhance the operational flexibility of the deployment and employment of naval mines prior to, at the outbreak of, and during hostilities.[77] In the past, RECO mines were a legally contentious technology on account of the potential danger it posed to commercial navigation. With the use of highly sophisticated sensors this concern has been significantly reduced. The addition of RECO mines would permit the deployment of naval mines in certain areas prior to the outbreak of hostilities, with no need for advanced notification or demarkation of safe sea lanes until the mines are activated. The relevance of this type of technology is extremely timely and valuable, for future conflicts will give little or no time or warning of impending hostilities. Remote control technology gives the United States a deterrent strategy that will not only signal U.S. intentions and resolve but give a tactical advantage in an area prior to the actual outbreak of hostilities. This type of strategy is available now and within the legal limits of international law.

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[77]Legal analysis obtained from the Mine Warfare/EOD Branch, OPNAV N852, as part of an ongoing study for the feasibility and legality of RECO mines in the future. Cited from "Legal Analysis of New Technology Mines," Naval Surface Warfare Center, Dahlgren Division.

E. SUMMARY

From a legal standpoint, a "turn on - turn off" capability would remove a major legal impediment commonly associated with the use of naval mines. Moreover, the requirement for air, surface, and subsurface assets for the laying of mines would be decreased, and whatever dangers posed to commercial surface and peaceful submerged navigation by active mines following de-escalation of tensions could be easily eliminated by simply turning the mines off. The greatest challenge for an effective and legally unobjectionable mining operation lies in the U.S. ability to further develop new technology which would incorporated the remote-control capabilities in such a way as to minimize the potential danger to commercial international navigation and to U.S. forces. Minimizing the danger of mines to peaceful navigation is an essential element in keeping within the legal limits of mining. Therefore, in addition to notification and channeling, a capability to activate/deactivate the mines or make them discriminate among targets would increase the span of situations where mining is acceptable under international law. Laying a RECO-controlled minefield could be seen as a weapons "predeployment" phase and no more an "act of war" than any other (pre) deployment of forces and ordnance in an already hostile region.[78]

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[78]Naval Surface Warfare Center Dahlgren Division R43, J. Scarzello letter memo, "Comments on RECO/IFFM," to A10, F. Brinck, Silver Spring, MD, 12 March 1993.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

This thesis focused on the advantages and disadvantages of a "pro-active" mine warfare strategy, with the aim of deterring future opponents from initiating a mining campaign. The United States has not only failed to recognize the strategic significance of an offensive mining and mine countermeasure strategy aimed at deterrence, but it has also failed to sustain an adequate capability in naval mine warfare, particularly in comparison to its other warfighting capabilities. Both "From the Sea" and the "Bottom-up Review" acknowledge the grave threat that mines present to the littoral area of operations, and identify mine warfare elements as key components of naval expeditionary forces.[79] History has shown that, so far, the implementation of these "acknowledgements" has taken a back seat to other "more important" priorities. The United States continues to observe the naval tradition of peacetime neglect of mine matters, and as Rear Admiral McCauley, Commander, Mine Warfare Force, predicted in 1973:

> Rarely will anyone in today's Navy argue against the effectiveness of mine warfare nor our vulnerability as a nation to its use by other powers. Yet the practical demise of the Mine Force in the U.S. Navy is already planned, a victim of other more sophisticated higher priority programs.[80]

If the United States is to successfully project forces ashore in support of future amphibious operations, it must project a sense of dire consequences toward nations who engage in mine laying activities. It must therefore possess the strategic and tactical capabilities that will deter, and if necessary, defeat the minelayer before he leaves the port. This offensively orientated strategy would not only send a clear message that the

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[79]1994 Mine Warfare Plan, p. 2.

[80]Melia, p. 133.

United States will no longer tolerate such acts of aggression, but project a long lasting deterrent for those nations who question U.S. resolve.

B. GENERAL CONCLUSIONS

The use of RECO mines before and during hostilities, needs to be examined further. Most important, the use of RECO mines, unlike armed mines, does not cross the legal limits of international law. Essentially, laying a RECO minefield is similar to creating a naval blockade, except that the risks to U.S. naval ships are less. Deploying a minefield would carry a clearer message of U.S. intentions than ambiguous diplomatic signals. This would be particularly true when dealing with renegade governments that show little concern for diplomacy or that openly support international terrorism. RECO mines can be used effectively as a psychological deterrent. When offensive mining is done properly, it could send just the right "deterrent" message, and may require only a few "unarmed" mines to be laid. Unfortunately, the Navy has invested very little in mine warfare as a whole, and even less in mining research and development. The Navy currently spends over $200 million each year for research and development on mine countermeasures, but spends only $3 million each year for the research and development of mines.[81] An even more discouraging fact is that the entire cost of all active and reserve U.S. Navy funding for mine warfare, accounts for less than one-half of one percent of the U.S. Navy budget.[82]

The decision to use offensive mining and mine countermeasures tactics before or during a crisis, is serious and carries potentially escalatory results, but the implications of not mining or neutralizing an enemy minelayer can be far more detrimental to the United States in the long run.

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[81]Horne, Charles F. III., RADM, "Modern Offensive / Defensive Mining for From the Sea - Regional Conflict," point-paper, 22 February 1994, p. 2.

[82]Dicker, R.J.L., "Mine Warfare Now and in the 1990s," International Defense Review 19, 1993, p. 294.

As the United States enters an era of smaller naval forces, armed with a doctrine that emphasizes littoral operations, the value of investing in the "weapon that waits" should be obvious. The investment must be balanced, equally supporting integration of naval mining into overall doctrine and continued investment into research and development of naval mines and mine-delivery systems. The U.S. Navy, faced with these realities, must establish a commitment to naval mining, or continue to be a second-class mine warfare force.[83] The United States can no longer afford to simply "damn the torpedoes," and fall victim to the numerous unpredictable aggressors that will surface in the future. It must take a more serious approach to naval mine warfare strategy, tactics, and technology, while embracing a proactive strategy of offensive mining and mine countermeasures aimed at deterring future aggressors, for the conflicts of the future will not wait for the United States to catch up.

C. SPECIFIC CONCLUSIONS

Specific conclusions regarding the implementation of an offensively orientated mine warfare strategy are these:

1. Current Problems and Issues with RECO and IFFM

First, although RECO and IFFM technologies has been available for the past 20 years, an insufficient investment in research and development have prevented them from being accepted as a viable and "safe" mining option. Secondly, the decision to employ RECO mining may not be fully accepted because of the potential political and military risks associated with the escalation of a conflict and the safety of U.S. forces afloat.

a. RECO and IFFM Solutions

A nominal investment in mining, as outlined in Chapter IV, would allow RECO and IFFM capabilities to meet acceptable safety standards by FY98. Once safety standards have been achieved and a working knowledge of the capabilities of each system

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[83]Keller, p. 46.

are understood by decision makers, the political decision to employ this capability may in fact be viewed as a more humanitarian solution than other options of military force.

2. Current Problems and Issues with Rules of Engagement

An on-scene commander does not have the authority to "defend" his ship from a vessel that is laying mines in international waters. This act of aggression places a United States naval asset, and the lives of those on board, in severe jeopardy.

a. Rules of Engagement Solutions

The JCS Rules of Engagement that govern the actions of an on-scene commander with respect to his inherent right of self-defense should be re-examined. It should be clear that a vessel laying mines in international waters does so with the intent of indiscriminately inflicting damage on another nation's assets. A nation which engages in this form of warfare should be seen as a direct threat to the safety of all who transit the high seas.

D. RECOMMENDATIONS

Implementation of the following recommendations should directly reduce the threat of future enemy mining, thereby, enhancing the United States ability to successfully project forces ashore in support of future amphibious operations.

1. RECO and IFFM

The U.S. Navy should invest sufficient funds in the Research and Development of RECO and IFFM capability which would enable both capabilities to be used safely and simultaneously, with little or no risk to friendly forces.

2. Rules of Engagement

Current ROE fail to adequately address the use of force against a known minelayer during peacetime, therefore, an on-scene commander is placed in a vulnerable and potentially dangerous position. These ROE should be re-examined and confront the inevitable threat U.S. naval forces will face in future conflicts. Once conclusive evidence is obtained that a vessel is engaging in minelaying activities, a commander must be

allowed to protect his ship and the lives of his crew. The right of self-defense should include the right to defend oneself against enemy mines.

3. Areas For Further Research

The following related areas are recommended for further research:

a. Offensive Mining of Inland Waterways

b. SEAL Delivery Vehicle (SDV) Mine Countermeasures

APPENDIX A. REST OF WORLD MINE PRODUCERS

NATION	NAME	TYPE	ACTUATION	WARHEAD
Chili	MS-L	Bottom	Magnetic	?
Chili	MS-C	Bottom	Magnetic	?
Chili	Stonefish	Bottom	M,A,P	500kg
Denmark	MTP-19	Bottom	Remote	300kg
France	TSM 3510	Bottom	M,A	530kg
France	TSM 3530	Bottom	M,MA	1000kg
France	FG 29	Bottom	M,A,P	600kg
France	FG 18	Bottom	?	?
Germany	G-1	Bottom	?	535kg
Germany	G-2	Bottom	M,A,P	?
Germany	IGM 10	Bottom	M,A,P	?
Germany	SAI	Bottom	?	?
Iraq	Sigeel/400	Bottom	Influence	400kg
Iraq	Al Muthena/35	Bottom	Contact	35kg
Iraq	Al Muthena/45	Bottom	Contact	45kg
Iraq	Al Kaakaa/16	Bottom	Remote	8165kg
Italy	MR-80/MRP A	Bottom	M,A,P	460kg
Italy	MR-80/MRP B	Bottom	M,A,P	630kg
Italy	MR-80/MRP C	Bottom	M,A,P	870kg
Italy	Manta	Bottom	M,A	150-180kg
Italy	Seppia	Moored	Influence	200kg
Italy	MAS/22	Bottom	Contact	17kg
Italy	MAL/17	Moored	Contact	17kg
Italy	TAR 6	Moored	Contact	175kg
Italy	WP 900	Bottom	M,A,P	?
Italy	VS-SM-600	Bottom	M,A,P	600kg
Japan	K-33	Moored	Contact	?
Japan	Type-70	Bottom	Influence	?
Japan	Type-56	Moored	Contact	136kg
Japan	Type-55	Moored	Contact	100kg
South Africa	Stonefish	Bottom	M,A,P	500kg
Sweden	Type 74	Moored	?	?
Sweden	Type 77	Bottom	Pressure	?
Sweden	GMI 100	Bottom	Influence	105kg
Sweden	MMI 80	Moored	Influence	80kg
Sweden	Bunny	Bottom	M,A,P	?
Sweden	LYDIA	Bottom	Acoustic	?
Taiwan	WMS 110	Bottom	Influence	?
Taiwan	WSM 210	Bottom	Influence	?

APPENDIX A. (CONT)

NATION	NAME	TYPE	ACTUATION	WARHEAD
UK	Sea Urchin	Bottom	M,A,P	1200kg
UK	Sea Urchin	Moored	M,A,P	1200kg
UK	Stonefish	Bottom	M,A,P	600kg
UK	Stonefish	Bottom	M,A,P	500kg
UK	Dragonfish	Bottom	2x Influence	80kg
UK	Mk 5	Bottom	?	?
UK	Mk 12	Bottom	?	?
UK	Mk 17	Moored	Acoustic	?
Yugoslavia	M70	Bottom	M,A	700kg
Yugoslavia	PLRM-1A	Drifting	Contact	10kg

(Source: 1992 Mine Warfare Plan)

APPENDIX B. MINE PRODUCING COMPANIES

COMPANY	COUNTRY	COMPANY	COUNTRY
AB PRECISION (POOLE) LTD	(UK)	REPAIR CRAFT LTD	(UK)
AEG AKTIENGESELLSCHAFT	(GER)	ROYAL ORDNANCE PLC	(UK)
AEROJET TECHSYSTEMS	(USA)	SA MARINE A/B	(SWE)
AUSTRALIAN DEFENSE INDUSTRIES	(AUS)	SHORT BROTHERS	(UK)
BAJ VICKERS	(UK)	SIMA	(PERU)
BAZAN	(SPA)	SOCIETA INDUSTRIALE CARDANA	(SPA)
BEAB	(SWE)	SPERRY GYROSCOPES	(USA)
BODENSEEWERK GERATETECHNIK GMBH	(GER)	TECHNICAL MANAGEMENT SERV.	(EDINGURGH)
BOFORS A/B	(SWE)	TECHNOVAR	(ITA)
BRITISH AEROSPACE AUSTRALIA	(AUS)	TEK SEA	(SWITZ)
BRITISH AEROSPACE PLC	(UK)	THIOKOL	(USA)
BRITISH AEROSPACE (DYNAMICS) LTD	(UK)	THOMSON SINTRA ASM	(FRANCE)
CHACONSA	(SPA)	THORN EMI ELECTRONICS LTD	(UK)
CHINA STATE SHIPBUILDING	(PRC)	VALSELLA MECCANOTECNICA	(ITA)
CONSUB EQUIPMENTOS E SERVICOS	(BRA)	UNDERWATER STORAGE	(UK)
COR INC	(USA)	WHITEHEAD MOTOFIDES	(ITA)
DALIAN WARSHIP INST	(PRC)		
DANISH AEROTECHNOLOGYSYSTEMS A/S	(DEN)		
DBE TECHNOLOGY GROUP	(UK)		
DEWEY ELECTRONICS CORP	(USA)		
DORNIER	(GER)		
DOWTY DEFENSE AND AIR SYSTEMS LTD	(UK)		
DYNAMIT NOBEL AG	(GER)		
EQUIPOS ELECTRONICOS EESA	(SPA)		
ERICSON RADIO SYSTEMS	(UK)		
EXPAL	(SPA)		
FABRICAS Y MAESTIANZAS DE EJERTO	(CHI)		
FAUN-HAG LAUFAD PEGNITZ	(GER)		
FERRANTI - CHEADLE HEATH DIVISION	(UK)		
FFV	(SWE)		
FREQUENCY ENGINEERING LABORATORIES	(FARMINGDALE, NJ)		
GEC AVIONICS	(UK)		
GEC-MARCONI ELECTRONIX	(UK)		
GIDROPRIBOR CENTRAL RESEARCH INST	(RUSSIA)		
GOODYEAR AEROSPACE DIVISION	(AKRON, OHIO)		
GOULD	(UK)		
HITACHI ZOSEN CO LTD	(JPN)		
HONEYWELL - UNDERSEA SYSTEMS DIV	(USA)		
HUNTING ENGINEERING	(UK)		
INDUSTRIAS CARDOEN	(CHILE)		
KENG CHIEH ENTERPRISES	(TAW)		
INISEL	(SPA)		
KRUPP ATLAS ELECTRONIK GMBH	(GER)		
LAWBOROUGH CONSULTANTS	(UK)		
LOCKHEED CORP	(USA)		
LOCKLEY MANUFACTURING	(NEW CASTLE, PA)		
LORAL SYSTEMS GROUP	(USA)		
MARCONI UNDERWATER SYSTEMS	(UK)		
MESSERSCHMITT - BOLKOW BLOHM - MBB	(GER)		
MISAR SPA	(ITA)		
MITSUBISHI	(JPN)		

(Primary Sources: Aero and Defense Markets Database, Jane's International Defense Directory 90, Jane's Underwater Weapons Systems 1994-95.)

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